Joint University of Southern Mississippi – U.S. Naval Oceanographic Office ECDIS Laboratory

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Abstract: In September 2001, the University of Southern Mississippi in conjunction with the United States Navy established an Electronic Chart Display and Information Systems (ECDIS) Laboratory to conduct research, development, test, and evaluation (RDT&E) on the capabilities and limitations of electronic charting systems, data, display, and updating services required for U.S. Navy and allied operations. To help attain the Navy's goal of Fleet-wide implementation of an ECDIS-N capability by 2004, the ECDIS Lab is used to conduct quality control and testing of electronic chart products produced by NAVOCEANO and other government agencies. Additionally, the lab is helping the Navy to gain a greater appreciation for and understanding of the use of electronic charts when operating in the shallow littoral areas of the world. The ECDIS Lab also serves as an information clearinghouse and demonstration center on available electronic chart data, systems, services, and technological advances [1]. This paper discusses the capabilities and accomplishments of the ECDIS Lab, the different electronic charting applications, electronic charting production and management software tools, and key accomplishments. More importantly, this paper will discuss the technical assistance the lab has provided to the Naval Oceanographic Office in their development of tactical overlays, and discuss its supporting role for other agencies such as the U. S. Navy Special Boat Unit 22 and the U. S. Army Corps of Engineers.

I. INTRODUCTION

The University of Southern Mississippi (USM) holds the leadership role in the marine sciences for the state of Mississippi. Since assuming that role in the early 1980s, the university has demonstrated its commitment to this mandate by establishing its marine science academic and graduate research program at John C. Stennis Space Center in 1986. That program evolved into the USM Department of Marine Science in April 1998. By fall 2001, this department had thirteen faculty members devoted to marine science education and research. With the assistance of the U.S. Naval Oceanographic Office (NAVOCEANO), the USM Department of Marine Science has developed a Master of Science degree in Hydrographic Science. The purpose of this new degree program is to provide graduate education to U.S. Navy employees and others in an area that is of increasing importance to naval operations. Additionally, the material covered in the program provided part of the basis for having the NAVOCEANO-USM Joint International Hydrographic Applied Science Program recognized in April 2000 by the International Federation of Surveyors (FIG)/ International Hydrographic Organization (IHO) at the Category A level.

USM furthered its efforts in hydrography by establishing a Hydrographic Science Research Center (HSRC). This new research center is part of the combined efforts of the Navy and USM to establish a National Center of Excellence (NCOEH) in Hydrography at the Stennis Space Center. The purpose of this facility is to focus more effort in an area that is a core competency of the Navy [2]. USM participates in this effort through its Department of Marine Science and the HSRC.

NAVOCEANO, with eight of the world's most modern survey ships, a solid core of experienced field hydrographers, a significant investment in surveying equipment, and the nation's most extensive holdings of bathymetric and hydrographic data, plays an integral role in the continuing development of the NCOEH. In 2001 the HSRC initiated several research projects that included the establishment of the Electronic Chart Display and Information Systems (ECDIS) Laboratory located at the University of Southern Mississippi's Stennis Space Center, Mississippi campus. The ECDIS Lab, jointly supported by NAVOCEANO and USM, was established to become a one-of-a-kind electronic charting laboratory by procuring, installing and maintaining Electronic Charting Systems (ECS) and ECDIS software, associated electronic chart-related equipment, systems, and data. Through the initial acquisition phase, the ECDIS Laboratory became a

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Navigation Demonstration Center and clearinghouse for electronic charting and navigation information. More importantly, the ECDIS Laboratory has progressed to the point of providing assistance to the U.S. Navy and NAVOCEANO as they expand their tactical products development as part of electronic charting applications.

II. ECDIS LABORATORY FACILITY

The ECDIS Laboratory consists of eight personal computers interconnected via a dedicated Local Area Network (LAN). Two of these computers serve as sensor simulators providing necessary real-time sensor data to run the various electronic charting applications. One computer serves as the electronic charting production and analysis platform. Another computer serves as the electronic chart data library warehouse, easily accessible by all platforms via the LAN. Five of the computers house the electronic charting applications that include Electronic Charting Systems (ECS), ECDIS, and U.S. Navy ECDIS-N candidates that have passed the Direct Read portion of the initial certification process required by the U.S. Department of Defense (DoD) [3]. Due to space limitations, some of the computers run several electronic charting engines, albeit not simultaneously. Since all computers are networked, all electronic charting applications have access to all electronic chart data.

The two sensor simulators provide the necessary information for navigational displays such as latitude, longitude, speed log, and depth. The latitude and longitude positions can be sent as either GPS or DGPS. All sensor information is sent using the NMEA 0183 standard protocol. Both simulators also have the capability of generating an Automatic Radar Plotting Aid (ARPA) target for real-time display. The two sensor simulators can be linked via the LAN to provide the same positional information to all machines to portray the same navigational display to the different ECS, ECDIS, and ECDIS-N candidate systems.

The production and analysis computer plays host to several different electronic charting production software packages and analysis tools. The two production suites consist of CARIS® and SevenCs ENC tools. The backbone of the CARIS suite is it's Geospatial Information System (GIS) module that supports the *CARIS® HOM* and *CARIS® DOM*, modules for Electronic Navigational Chart (ENC) and Digital Nautical Chart (DNC®, respectively). *CARIS® HOM* and *DOM* are also supported with additional modules to create Additional Military Layers (AMLs). The SevenCs suite consists of *ENC Analyzer*, *ENC Optimizer*, and *ENC Designer*. Other electronic chart analysis toolkits include *dKart Inspector*™ for postproduction analysis of ENCs, and *VPF Validator*™ for postproduction analysis of DNC®. Visual quality control analysis tools include several viewers such as *SeeMyDEn*c, *Easy ENC*, and the Full Utility Navigation Demonstration (FUND).

The electronic chart data warehouse provides up-to-date charts to all systems depending on licensing agreements. Because of the cost of licenses, some are limited to only one system. For instance, the Admiralty Raster Chart Service (ARCS) license is dedicated to Offshore System's Electronic Chart Precise Integrated Navigation System – Military (ECPINS-M). The chart library consists of the DNC® folio (the only complete worldwide vector format database), the entire ARCS folio of the world, S-57 datasets from countries such as Canada, United States, Mexico, Peru, Japan, and Australia among others. Many of the S-57 datasets are test datasets downloaded from hydrographic offices and agencies Web sites or provided by ENC service providers such as Primar. Other data housed in the digital library are Maptech's BSB (raster format) charts of the United States, the United Kingdom's Additional Military Layer (AML) test data set, and the U. S. Army Corp of Engineers' latest release of Inland ENC of several major rivers of the United States.

The Laboratory has one of the largest collections of ECS, ECDIS, and ECDIS-N Direct Read electronic charting applications housed within a single setting in the world (see Table 1). This list is dynamic and constantly changes to meet our customers' demands depending their electronic charting application interests and requirements.

TABLE 1
ECS and ECDIS systems installed at the USM-NAVOCEANO ECDIS Lab

Manufacturer	System
Offshore Systems	ECPINS®-M
Transas Marine	NaviSailor 2500 / 3000 / 3100
ICAN	Aldebaran II
SPAWAR	Integrated Charting Engine (ICE)
Raytheon	Pathfinder®/ECDIS
Sperry Marine	Voyage Management System
SevenCs	ORCA Master
C-MAP	ECS
Pinpoint	Cap'n Navigator
Maptech®	Offshore Navigator®
Nobeltec™	Visual Navigator
U.S.C.G.	COMDAC INS

Using sensor simulators (e.g., GPS) with these systems, the ECDIS Lab is able to create a near real-time operational test of data, displays, and systems. Not only does this demonstrate interoperability between electronic charting applications, it also ensures interoperability of the chart data. In some cases, one electronic chart system may be more forgiving in electronic chart dataset errors and easily displays the data. On the other hand, another system may not be able to display the data because of the same errors.

III. ACCOMPLISHMENTS

An initial grant provided by the U.S. Navy supported the development of the ECDIS Lab. From September 2001 – June 2002, the majority of the time was spent acquiring hardware, electronic charting systems, and software tools. Early on, a market approach was also developed to increase awareness of the ECDIS Lab's location at the Stennis Space Center. At the Stennis Space Center, briefings were provided to the Commander Naval Meteorology and Oceanography Command, the Naval Oceanographic Office and the Naval Research Laboratory Detachment. Other briefings included the Navigator and Hydrographer of the U.S. Navy, National Imagery and Mapping Agency (NIMA), and several Directors of the International Hydrographic Bureau.

Working in close cooperation with the NAVOCEANO, the ECDIS Lab provides technical assistance and services, functions as an electronic charting demonstration center, and installed and maintained several electronic charting systems on their 48-foot Bertram training vessel. In particular, the ECDIS Lab provided technical assistance for NAVOCEANO's electronic product development and preliminary quality control of DNCs® in association with their co-production agreement with NIMA. As an example, the laboratory would receive an updated DNC® from NAVOCEANO and would load it in several different ECDIS and ECS systems having DNC Direct Read charting engines. Even though the electronic chart could be verified using an electronic chart production software package and postproduction viewers such as SeeMyDEnc™, there were some instances when the data could not be properly displayed. This process led to the creation of a DNC® validation process and plan for NAVOCEANO.

NAVOCEANO has a large amount of tactical data including high-resolution bathymetry and the worldwide minelike contact database. While these are not part of an ENC or DNC®, they could be provided as an addition to the DNC® for critical tactical information during operations in the littoral zone. To this end, the lab assisted NAVOCEANO in developing a high-density contour overlay or Tactical Electronic Chart Overlay (TECO) in support of one of their customers. At first, NAVOCEANO produced a stand-alone vector product format (VPF) layer containing high-density contours and when draped over the DNC®, the DNC® lost its navigational functionality [4]. In other words, the VPF overlay masked the underlying DNC®. Based on the DNC® data model, the lab determined that the best course of action would be to modify appropriate thematic layers associated with bathymetry and in effect, create an "enhanced" DNC™.
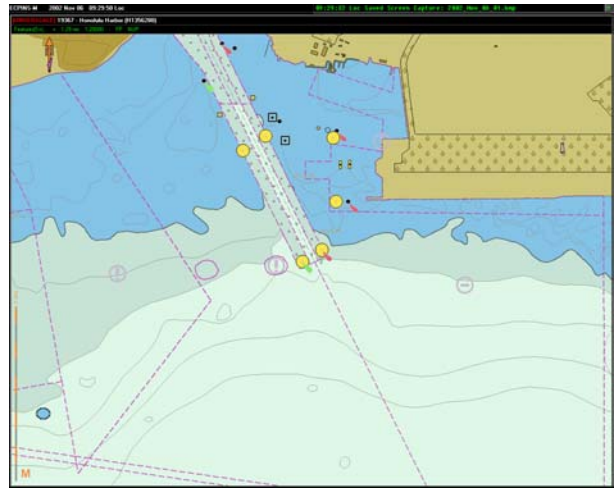

Figure 1. Pearl Harbor DNC®

Figure 2. Pearl Harbor Enhanced DNC®

Figure 1 depicts the entrance to Pearl Harbor as shown by the DNC®, while Figure 2 shows the "enhanced" DNC. While this process basically met the customer's needs, it was very time consuming. To shorten the production process, NAVOCEANO produced a similar high-density contour layer TECO utilizing the S-57 data transfer format, and draped it over a DNC® (see Figure 3). This took only a matter of hours to produce versus weeks for the "enhanced" DNC. The only drawback in using the S-57 TECO draped over a DNC® was that it was not possible to query its metadata. Only the underlying DNC® retains its navigation function and not the "enhanced" DNC. This shortcoming may not fulfill a tactical requirement but, in times of crisis it may be the only product available on such a short notice. At a minimum, it could also meet most needs through inference and textual annotations.

Figure 3. S-57 Overlay Draped over a DNC®

IV. CURRENT PROJECTS

A. DNC® Validation Process and Plan

As previously mentioned, the ECDIS Lab was tasked to develop a validation process and plan for updating DNC® based on recent hydrographic surveys conducted by NAVOCEANO. This process starts with base-lining inherent errors (if any) that may be associated with a DNC®. These errors are non-critical and do not affect the navigation functionality of the DNC®. Normally, when using the VPF Validator software, the process continues through the production phase utilizing quality assurance modules within the electronic chart production software (e.g., CARIS™ software tools are used). Next, a visual quality control check is performed using both the production software and available viewers such as SeeMyDENC™ by SevenCs. A further quality control check is performed using VPF Validator by comparing errors generated in the final phase with the base-line error check. The final quality control test is performed by an operational test using ECDIS-N candidate systems that have passed the Direct Read validation by NIMA. This final check ensures that the chart lineage is up to date and conducts random queries for attributes on a representative number of objects as a means of data quality assurance. Throughout this phased validation process, documentation reports generated by the production software, screen shots, and historical work progress are collected and collated into a documented report on the integrity of the updated DNC®. This data validation process has generated interest by other electronic charting production facilities and discussions are underway with the lab to provide similar services for other types of electronic chart data.

B. Riverine Electronic Chart Pilot Project

As part of the Masters of Science degree program in Hydrographic Science at USM , students typically conduct a hydrographic survey during their final trimester. During this June-July 2002, the class surveyed a significant portion of the Pearl River that borders the Stennis Space Center and divides a limited area between Louisiana and Mississippi (see Figure 4). The U. S. Navy's Special Boat Unit 22 (SBT-22), a tenant activity at Stennis Space Center, uses the Pearl River and other tributaries to conduct riverine warfare training and tactics. Since no electronic chart data exists for the Pearl River, SBT-22 expressed an interest in the dataset with potential applications to include additional tactical data provided by NAVOCEANO. The ECDIS Lab hosted a meeting that included representatives from NAVOCEANO, U.S. Army Corps of Engineers (USACE),

Figure 4.The University of Southern Mississippi Survey data of the Pearl River, MS

USM and later, SBT-22. The objective of the meeting was threefold:

1) Provide NAVOCEANO with a segway to support SBT-22 through the use of the USM dataset,

2) Promote USM's M.S. in Hydrographic Science program as an avenue for further education for their workforce,

3) Investigate potential collaborative efforts with the USACE and other government agencies in terms of producing a Pearl River ENC based on USM Student Hydrographic Survey of 2002.

V. LOOKING TOWARD THE FUTURE

As the U.S. Navy migrates to a "paperless bridge," many additional capabilities of ECDIS will be realized such as the integration of Automatic Identification System (AIS) and NATO Additional Military Layers (AMLs). This will require decision-making advice, testing and evaluating new electronic chart products, and interoperability analysis. The ECDIS Lab is working toward gaining a simulated AIS feature to support the electronic charting systems installed at the ECDIS Lab. In the future, display aspects of these applications will become more important as ECS and ECDIS become overloaded with additional information for

display. These will include Automatic Radar Plotting Aid (ARPA), AIS, and overlays whether they are Marine Information Objects (MIO), NATO AMLs, or USN TECOS. At some point, there has to be a determination of information and display overload that has created a situation where the mariner has "lost the bubble" or navigation picture.

A. Interoperability

As more electronic charting systems become involved in the ECDIS-N certification process, the ECDIS Lab will include those systems as part of its inventory. Although the U.S. Navy has a stated goal of having an ECDIS-N on every ship by the end of FY04 [5], based on a recent assessment by the Navigator of the Navy this may not be realistically achieved until FY10 [6]. During this transitional period, many ships will continue to use ECS and ECDIS that were procured to improve overall "situational awareness." Other allied navies will also increase their dependence on electronic charting applications, and may not be using systems that are capable of meeting U.S. Navy ECDIS-N requirements. This may tax interoperability capabilities between different allied navies, as well as within the U.S. Navy. The ECDIS Lab can help identify and propose solutions to these interoperability issues particularly when employing additional tactical information in these systems.

B. Testing and Evaluation

As more ECS, ECDIS, and ECDIS-N systems are fielded, there will be an increased need to ensure the data is displayed in a correct manner and that it meets required performance specifications. It has also become evident that there is a large amount of data waiting to be developed into additional layers to be draped over an electronic chart.

Looking to the future, the ECDIS Lab will continue to play a key role in testing and evaluating the capability and limitations of electronic charting systems to meet U.S. Navy missions, and those of other government agencies as well.

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